



Memorandum

To: Aaron Miller

Date: August 16, 2007

From: Terri Bowers

Subject: Preliminary Analysis of Surface Scraping and One Inch Sampling Data

The purpose of this memo is to present a preliminary analysis of sample data collected by the Doe Run Company in June and July 2007 from residential properties in Herculaneum, Missouri. This data analysis was conducted by Gradient Corporation at the request of Doe Run. The samples were collected as nine-point composites in each of four quadrants in a residential yard from two depth intervals: surface scrapings (approximately 1/8th inch) and a 0-1 inch composite. Samples were collected both from properties that had been previously remediated, as well as from several properties that have never been remediated. This memo examines the data collected from remediated properties first, followed by an analysis of the data collected from non-remediated properties.

The primary conclusions of the analysis are:

- The data show no evidence that surface scraping samples provide a more appropriate estimate of soil lead concentrations for analysis of either recontamination or childhood risk than the full one inch sample that has been taken in the past.
- The data provide evidence that lead deposited on surface soils works its way down through the soil column to depth with time. As a result of this phenomena together with the decreasing emissions of the last few years, the maximum soil lead concentration is not found on the surface for those properties that were never remediated or remediated sufficiently in the past. This is consistent with expectation.
- This data, combined with historic data, show evidence that the surface lead levels stop increasing (*i.e.*, reach an "equilibrium" concentration) with time, and/or surface concentrations decrease with time as a result of decreasing emissions. This is also consistent with expectation.
- Samples with soil lead concentrations above the time critical value of 1200 mg/kg are all, with one exception, found on properties or quadrants that have not undergone remediation. This means that the test protocol was broader than its stated purpose of measuring recontamination of previously remediated soils.

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Remediated Properties

Data for remediated and non-remediated properties were grouped separately for this analysis. Some remediated properties had select quadrants that were not remediated due to access or other issues, and those quadrants were grouped with the non-remediated properties. Figures 1-3 show the concentrations of Pb in surface scrapings vs. in one inch samples for remediated properties and quadrants as a function of remediation status and exposure area (EA)¹, for EA 1 (Figure 1), EA 3 (Figure 2), and EAs 4 and 5 (Figure 3)². Data are shown with different symbols based on remediation date. Properties remediated in 2002 are divided into two categories: those remediated in January through July (2002A) and those remediated in August through December (2002B). This distinction in the 2002 remediation dates is made because of the SIP controls that went into place at the beginning of August in 2002. On all figures, a one-to-one line is plotted that shows where the data symbols would fall if the concentrations were equal in the surface scraping and one inch samples. Data that plot above this line represent samples where the concentration is higher in the surface scrapings, while data that plot below this line represent samples where the concentration is higher in the one inch sample. A large amount of the data plot close to the one-to-one line on all figures, indicating that the sample results are largely the same, with differences most likely due to typical soil heterogeneity³.

In order to better examine whether the relationship between surface scrapings and one inch samples varies with remediation date, Figure 4 shows all quadrant data for remediated properties in all EAs, with a trend line placed through each year's data set. The slopes of the trend lines increase in the following order: 2002A, 2001, 2002B, 2004, 2007, 2003, 2005. There is substantial uncertainty in these trend lines due to the limited sample size of the data sets (more limited for some years than others) and the effect of outliers. However, the lowest slopes are for the earliest remediation dates, while the later remediation dates have higher slopes. This observation is consistent with a conceptual model of soil mixing with depth over time, decreasing the differences between surface scraping and one inch concentrations. It is also consistent with the reduced emissions over the last few years, where higher soil lead concentrations associated with earlier, higher emissions, have now been mixed to some depth in the soil column.

¹ Exposure areas (EA) are as defined in the Draft Community Risk Assessment (Gradient, 2006) and are used here as a proxy for distance from the facility. EAs 1 and 2 are close to the facility, EA 3 is farther to the north, and EAs 4 and 5 are to the northwest

² The only EA 2 property in the dataset was unremediated.

³ This observation is less true when looking at the subset of the data for those properties included in both this sampling and EPA's ongoing recontamination sampling. In that smaller dataset, about two-thirds of the samples have higher lead concentrations in the surface scraping samples than in the one inch samples.

A second comparison of surface scraping vs. one inch composite results are presented in Table 1, which lists properties where a quadrant was found with a concentration above 400 mg/kg in either the surface scraping or one inch sample, but below 400 mg/kg in the companion one inch or surface scraping sample. In other words, these are quadrants that would be identified as exceeding the U.S. EPA soil screening level for lead under one sampling methodology, but not under the other. The table includes 17 quadrants where the surface scraping lead concentration exceeds 400 mg/kg while the one inch concentration is below 400 mg/kg, and 13 quadrants where the one inch concentration exceeds 400 mg/kg while the surface scraping concentration is below 400 mg/kg. Three properties have quadrants that fall into both categories. Some of this disparity results from the effects of soil heterogeneity and does not represent a significant difference in concentration. In order to more closely look at differences between surface scraping and one inch samples that might represent effects in addition to soil heterogeneity, the last column in the table identifies those quadrants where the difference in concentration between the surface scraping and one inch samples exceeds a factor of 2. The factor of 2 is chosen arbitrarily. Of this subset, there are an approximately equal number of quadrants where the surface scraping concentration substantially exceeds the one inch concentration and where the one inch concentration substantially exceeds the surface scraping concentration. As a result, the surface scraping samples do not appear to be a better or more sensitive way to identify or quantify recontamination of properties.

Non-remediated properties

Soil lead concentrations for properties that have never been remediated are shown on Figure 5. This figure also includes data for unremediated quadrants from properties that were otherwise remediated. A large proportion of the data for the non-remediated properties and quadrants that do not fall close to the one-to-one line have higher soil lead concentrations in the one inch samples than in the surface scraping samples. This can be seen in the larger proportion of symbols that plot substantially to the right of the one-to-one line in Figure 5. This is in contrast to the pattern seen on remediated properties in Figures 1-3. This result can be explained by the effect of reducing emissions over the last few years in Herculaneum. Figure 6 is a schematic of soil lead concentration as a function of depth (depth is plotted on the vertical axis with the ground surface at the top of the diagram). Two curves are shown on the diagram. Remediated properties will start with uniformly low levels of lead, and then recontaminate preferentially at the surface. A combination of physical, chemical and biological processes will result in mixing of the soil column and, with time, lead will become distributed to some depth. If emissions were to remain constant after the remediation date, the maximum concentration of lead in soil would remain at the surface. However, non-remediated properties, or properties that were remediated some years in the past,

will show a different trend with soil depth because the maximum emissions occurred several years ago. These previous higher soil lead levels have worked their way down through the soil column, and as a result, the maximum concentration of lead in soil occurs at some (unknown) depth, rather than on the surface. The one inch composite samples therefore have a higher concentration than the surface scraping samples in this scenario.

All but one of the non-remediated properties included in the current sampling event were also sampled during the site characterization work done in 2001-2002. Figure 7 shows the relationship between the 2001 and 2007 soil lead concentrations in the one inch samples. The diagram includes a one-to-one line, where the concentrations are equal. This figure shows that a large portion of the data fall close to the one-to-one line, while departures from the one-to-one line fall approximately equally to each side, some where the 2007 sample has a substantially higher concentration than the 2001 sample and some where the 2001 sample has a substantially higher concentration than the 2007 sample. There is no single explanation for these "outlier" results. The large amount of data with very similar concentrations in 2001 and 2007 indicate that the soils have approached an "equilibrium" concentration.

Several quadrants were found to have a concentration above 1200 mg/kg in either the one inch or surface scraping samples, and these are summarized in Table 2. With the exception of the property at 650 Main St., none of these quadrants have been remediated. Note that there are more exceedances in the one inch samples than in the surface scraping samples, and where both samples in a quadrant exceed 1200 mg/kg, the one inch sample generally has the higher concentration. This is the same observation described in Figure 5 and discussed above. It likely has to do with decreased emissions in the recent past and soil column mixing such that the maximum lead concentrations occur at some depth rather than on the surface.

Table 1. Identification of properties with Pb concentrations in soil above 400 mg/kg in one sample but not the other

Address	Exposure Area	Quad	One Inch Pb Soil (mg/kg)	Surface Pb Soil (mg/kg)	Factor > 2?
729 Circle St.	1	3	185	483	yes
306 Main St.	3	1	168	986	yes
310 Main St.	3	1	117	435	yes
501 Main St.	3	1	150	1053	yes
479 Main St.	3	3	122	764	yes
561 Main St.	3	2	340	417	
551 Main St.	3	1	335	527	
		2	158	473	yes
783 Joachim Ave.	5	2	123	766	yes
341 Main St.	3	1	275	434	
454 Hill St.	4	3	393	428	
227 Joachim Ave.	4	2	377	433	
812 Brown St.	1	1	365	443	
		2	267	441	
650 Main St.	3	2	260	409	
		3	874	235	yes
345 School St.	2	1	1230	236	yes
		3	391	482	
562 Reservoir	3	1	406	282	
		2	322	445	
		4	466	267	
262 Main St.	3	3	453	137	yes
887 High St.	1	3	498	394	
359 Station St.	1	1	424	219	
		2	442	262	
168 Joachim Ave.	4	3	999	261	yes
485 Main St.	3	1	632	289	yes
		3	586	130	yes
407 Burris St.	1	1	591	367	
		4	548	368	

Table 2. Summary of Pb Concentrations in Soil above 1200 mg/kg

Address	Exposure Area	Quad	One Inch Pb soil (mg/kg)	Surface Pb soil (mg/kg)	Comment
887 High St.	1	4	2147	2200	Quadrant not remediated due to patio, car port, swimming pool and shrubs
345 School St.	2	1	1230		No record of property ever being remediated, sidewalk replaced in front of house by city may have impacted yard.
		2	1937		
650 Main St.	3	4	2980		No explanation.
589 Main St.	3	3	2076		Quadrant not remediated due to deck, patio, and no access
		4	5753	1727	Quadrant not remediated because it is a 5-6 foot strip with large trees adjacent to driveway; road water runoff observed into this quad
747 Brown St.	1	1	2593	1673	Refused remediation
		2	2750		
933 Church St.	1	3	1220		Refused remediation
		4	2170	1290	
710 Circle St.	1	3	2153		Refused remediation
774 Circle St.	1	2	3887	1367	Refused remediation
		4	1313		
357 Curved St.	1	1	2117		Refused remediation
		2	1383	1370	
		3	8863	1257	
672 Main St.	3	1	1293		Refused remediation
		2	2400		
		3	4793	3787	
		4	7203		
221 Joachim Ave.	4	1	1750		Refused remediation
		2		1887	

Figure 1
Remediated Soil: Soil Lead Concentration by Remediation Year, All Quads Together EA1

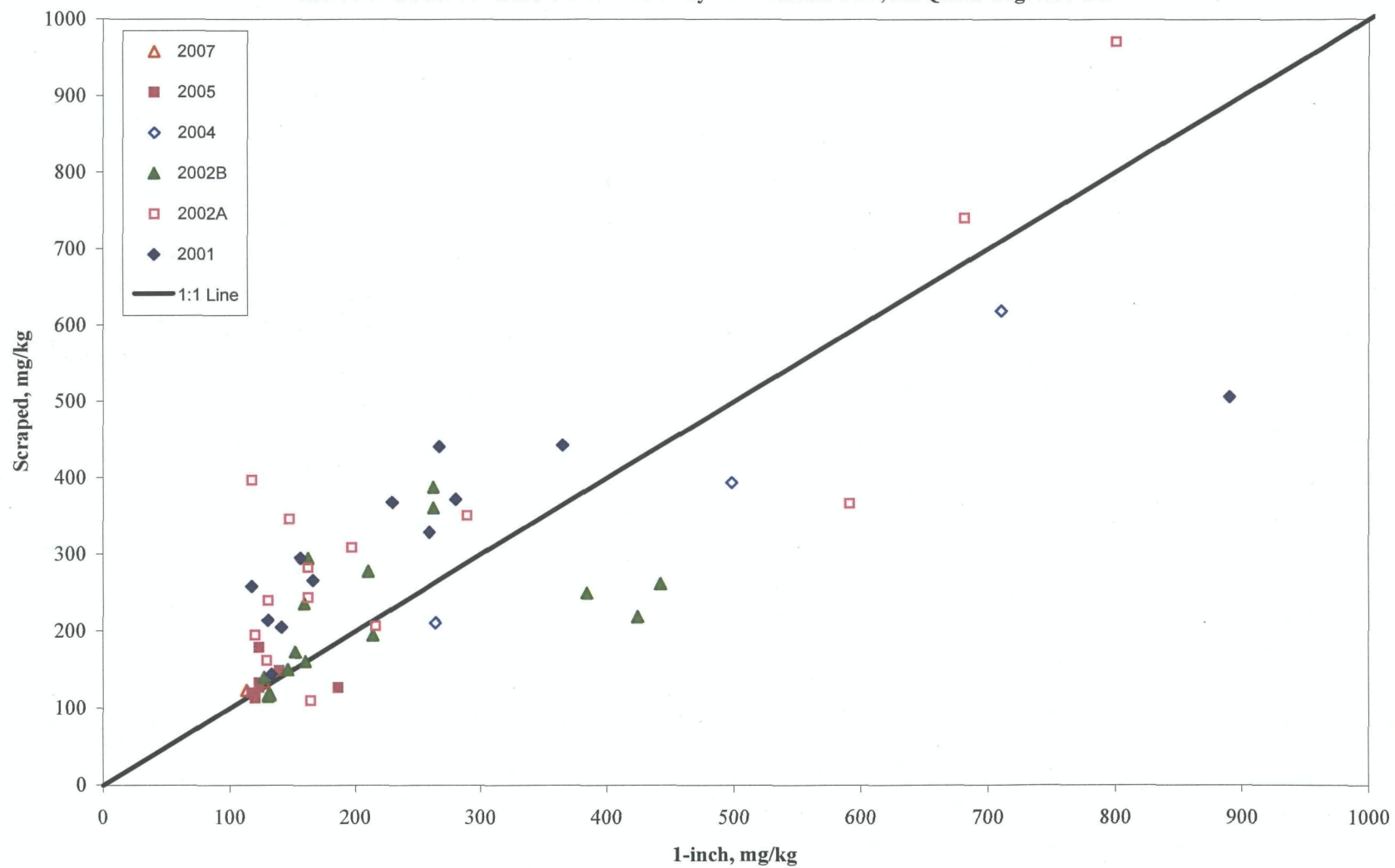


Figure 2
Remediated Soil: Soil Lead Concentration by Remediation Year, All Quads Together EA3

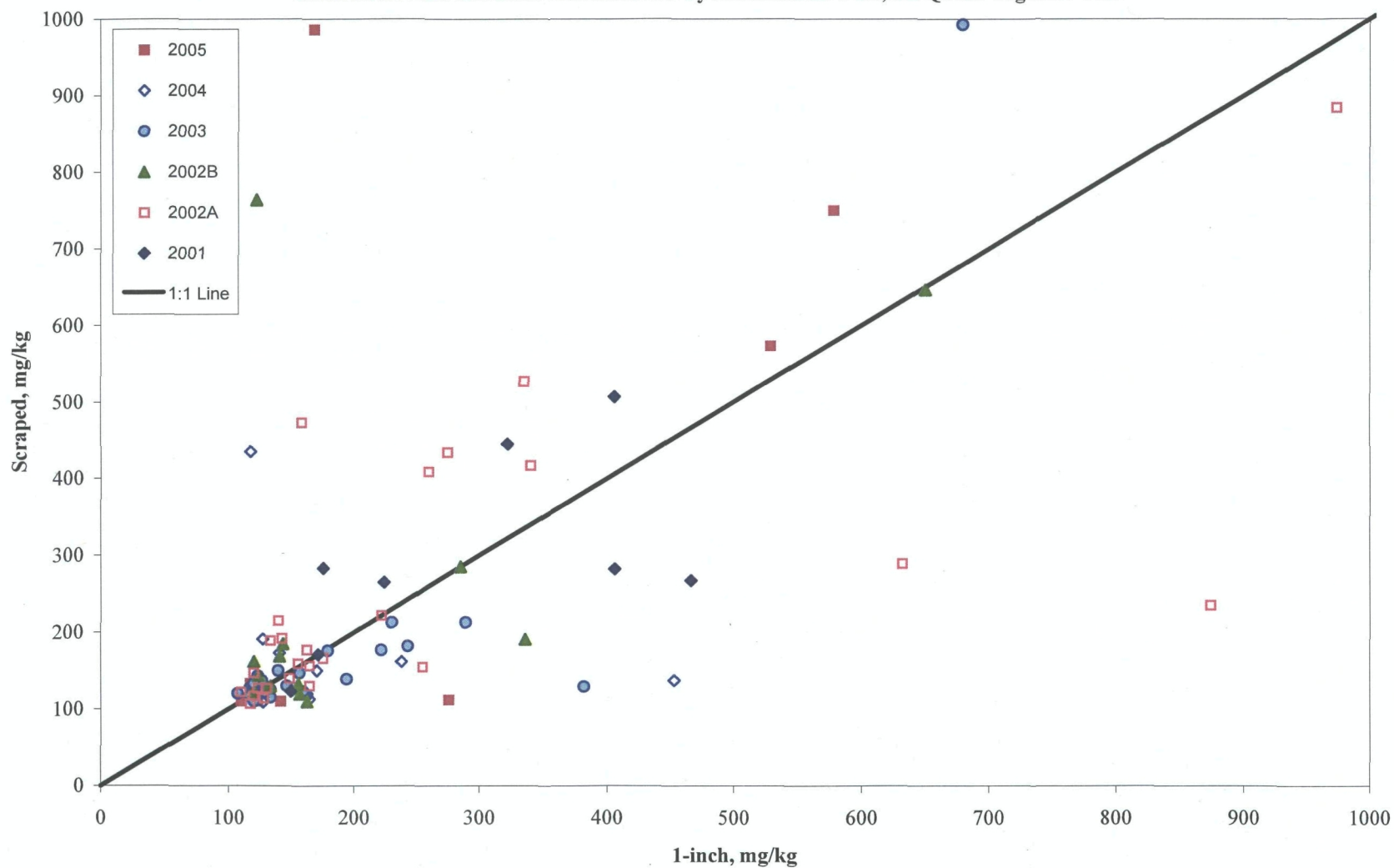


Figure 3
Remediated Soil: Soil Lead Concentration by Remediation Year, All Quads Together EA4 & EA5

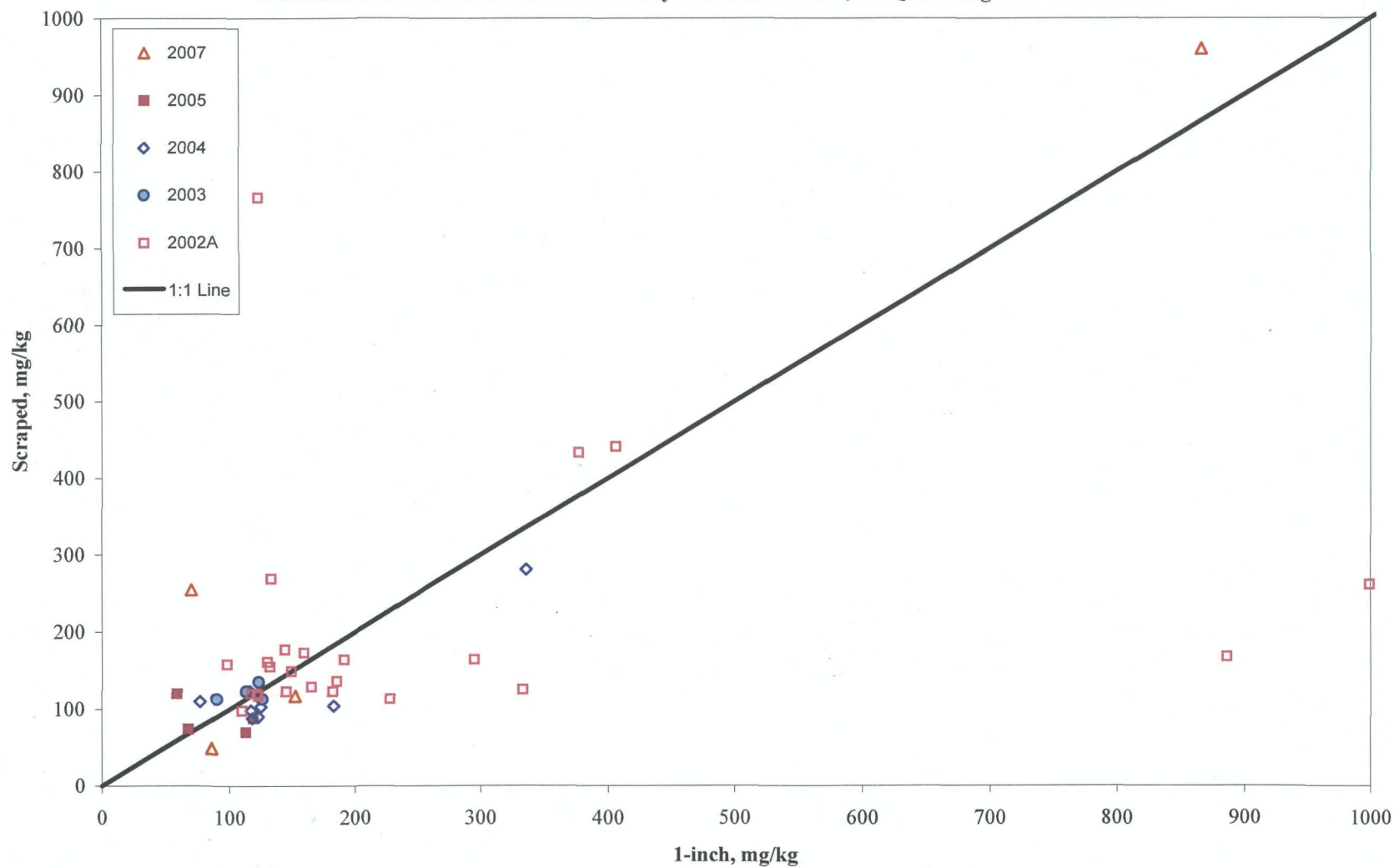


Figure 4
Remediated Soil: Soil Lead Concentration by Remediation Year, All Quads Together

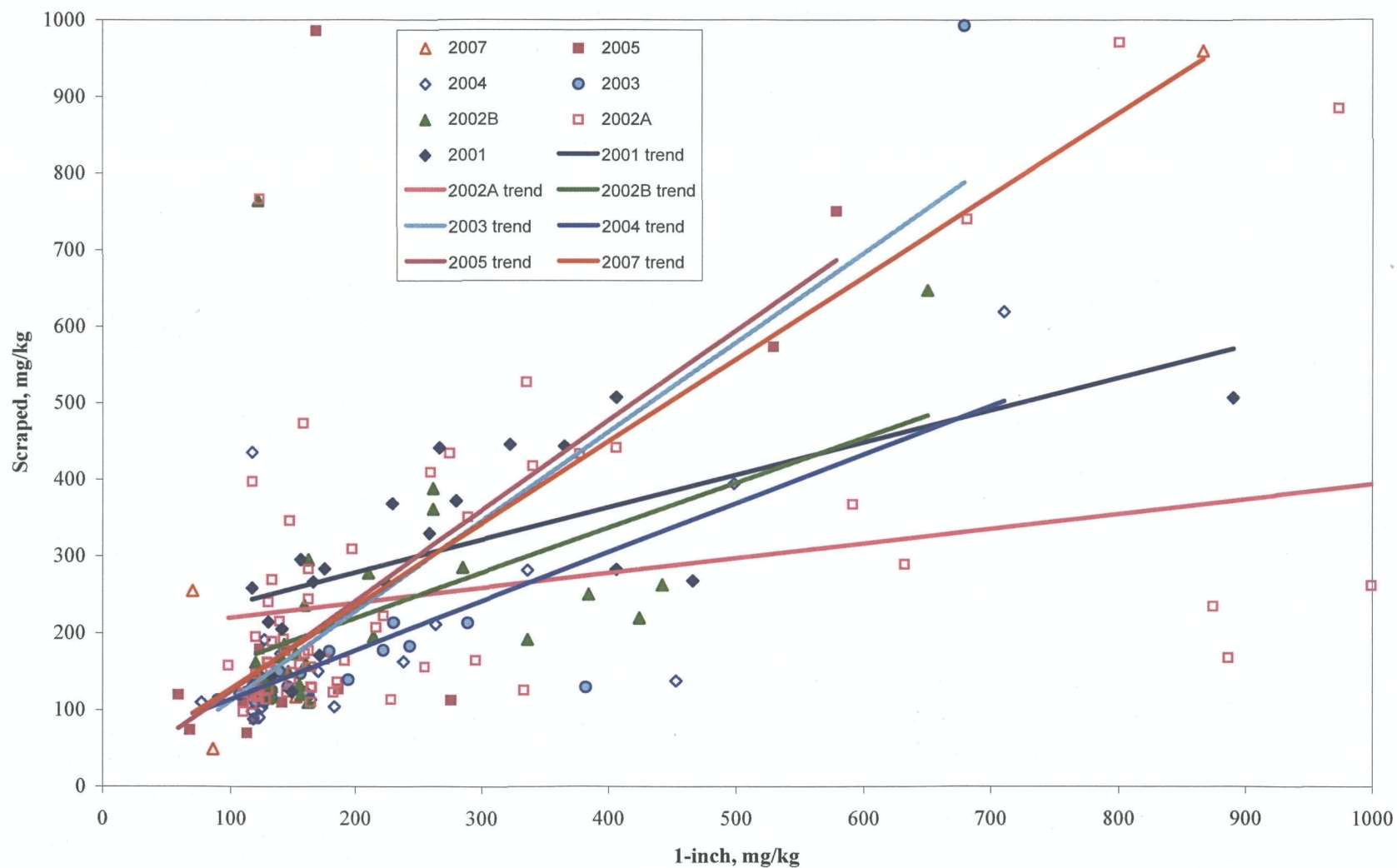
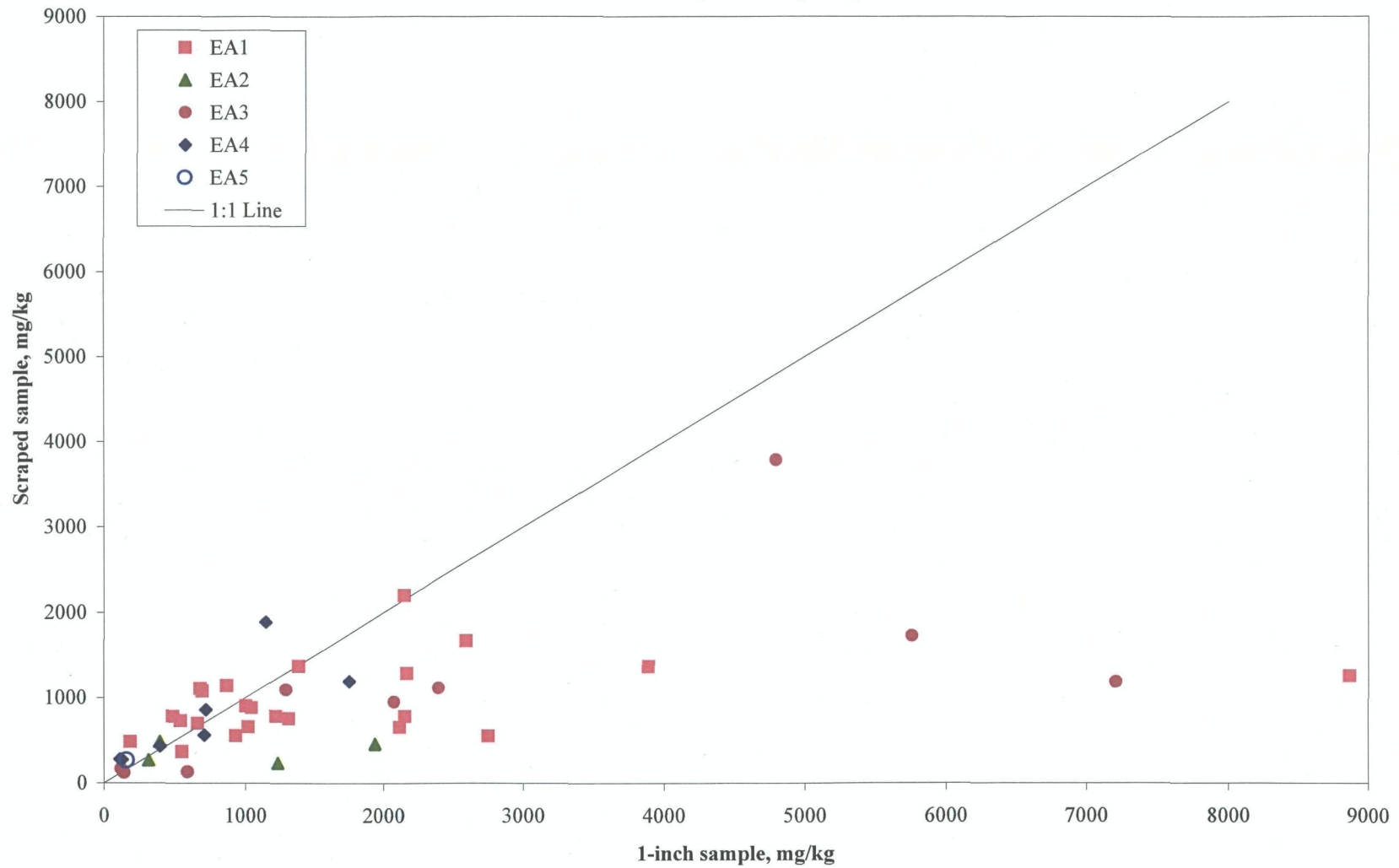
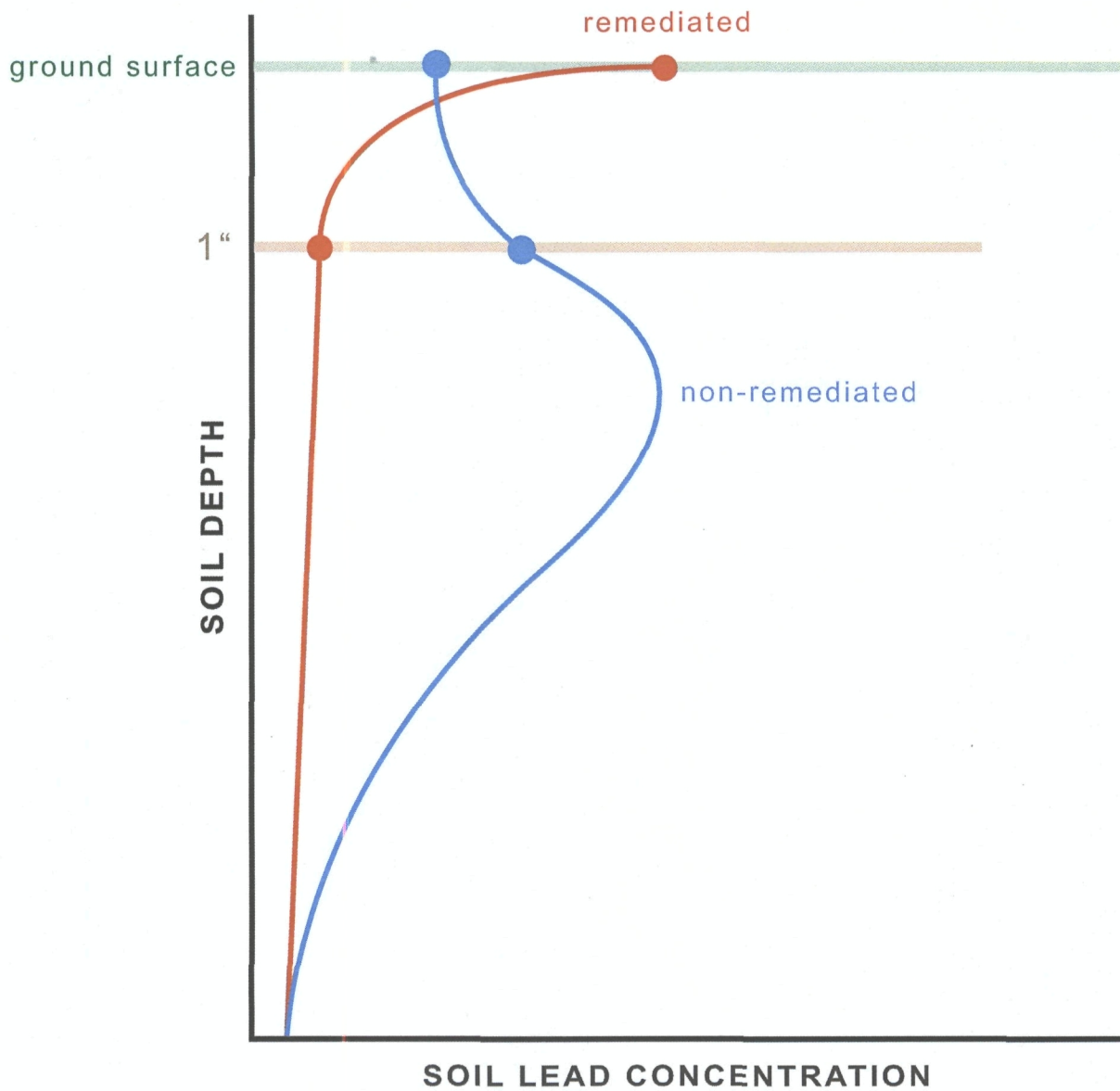


Figure 5
Non-remediated Properties, by Exposure Area





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Figure 6

Schematic of Soil Lead Concentration vs. Depth

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Figure 7: Soil Lead Concentrations in 2007 vs. 2001/2002

